design. Section IV examines policies toward designated entities. Section V considers the use of experimentation to refine the auction design so as to further the Commission's objectives and discusses how to evaluate the success of the auctions. The summary and conclusions are contained in section VI. A copy of my curriculum vitae is provided in Appendix A. Sample forms on which bidders could record their bids and on which the Commission could record those bids are contained in Appendix B. Finally, Appendix C discusses several technical matters: simultaneous auctions of Channel Blocks A and B, reserve prices, royalty payments, and risk aversion.

II. Recommended Auction Design and Its Advantages

A. Summary of the Recommended Auction Design

My recommendation is that the Commission employ multiple rounds of sealed-bid auctions,[4] simultaneously auctioning every geographic region[5] for a given block of the spectrum, but sequentially auctioning the seven spectrum blocks. Effectively, multiple rounds of sealed-bids represent a written version of the *English* auction. After a given round, the maximum bid obtained in that round is announced to the bidders, and the maximum becomes the minimum valid bid for the next round (a minimum increment should be imposed to ensure a speedy termination of the auction). The details of the recommended auction design are provided in section III.

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[4] This auction form is mentioned in the Notice at footnote 26.

[5] Given the large number of BTAs to be auctioned, it may be desirable to divide the nation into several broad regions, auctioning every BTA in a broad region simultaneously, then auctioning the BTAs of a second region, and so forth.

B. The Importance of Information Release in Auctions

A central issue in auction design is the release of information during the course of the auction to the bidders. This subsection explains how the release of information affects bidding behavior, and why ascending bid auctions tend to produce more efficient outcomes and higher average prices than first-price, sealed-bid auctions.[6] Bidding behavior in auctions is determined by the information held by the bidders. Typically bidders know something, but not everything, about the value of the item for sale.[7]

For example, potential bidders for PCS licenses are uncertain about consumer demand, future technological developments, the nature of future competition, the costs of implementing PCS, and the resale value of PCS licenses. All of these factors influence the profitability and hence the value of PCS licenses. Given these uncertainties, the auction should be designed to provide bidders with as much information as possible, which means providing information about other bidders' estimates of the licenses' values in the process of running the auction.

By their nature, auctions tend to allocate the licenses to the most optimistic bidders, a phenomenon known as the *winner's curse*. Selling by auction ensures that the licenses will typically be allocated in an efficient manner, because the bidder who can put the license to the highest value use is willing to pay more, and hence will tend to win the auction. However, each bidder will take into account that, if it wins the auction, all the other bidders had lower estimates of the value of the license. Typically, knowing that other bidders assigned a lower value to the license means that each bidder would like to

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[6] See Milgrom and Weber (1982), "A General Theory of Auctions and Competitive Bidding," *Econometrica*.

[7] An applicant's "valuation" of a license equals the maximum that it would pay for that license. Applicants will generally bid less than their valuations.

revise downward their estimate of the value, to adjust for the fact that it was the most optimistic bidder.

First-price, sealed-bid auctions, which permit no revision of bids, require a bidder to adjust for the winner's curse in preparing its bid. In contrast, in ascending bid auctions, a bidder can base its bids on the bidding behavior of others. Seeing other bidders bid aggressively, for example, causes each bidder to revise its estimates upward, because the bidders observe that others also have high estimates of the value of the item for sale. Upon observing faltering and weak bidding, each bidder revises downward its estimate of the value. Essentially, ascending bid auctions insure a bidder against major mistakes in estimating the value, since a major error will become apparent. Major underestimates of the value are revealed by aggressive competition, and major overestimates of the value are revealed by other bidders dropping out unexpectedly early in the bidding. In summary, *ascending bid auctions release more information about the value of the license than sealed-bid auctions.*

The information released in ascending bid auctions increases the revenue accruing to the seller relative to one-time, sealed bid auctions. Eventually an ascending bid auction becomes a competition between two bidders, the one with the highest value of the license and the one with the second highest value. As the bids increase, bidders are observed to drop out or cease bidding. The effect of this is to provide information to the remaining bidders, information about the bidders with lower estimates of the value. By providing this information, ascending bid auctions tend to make the two highest bidders' information similar, and hence their valuations of the license closer. This brings the second highest bidder's estimate closer to the actual expected value of the license, and hence the price paid becomes closer to the actual value. *Ascending bid auctions produce higher prices than first-price, sealed-bid auctions.*

Therefore, insuring the bidders against massive overestimates of the value of the license by releasing information makes them more aggressive in the bidding, and in

particular makes the second highest bidder more aggressive, which drives the price closer to the actual value of the license. For this reason, it is in the seller's interest to release all available information about the value of licenses to the bidders. Thus, the Commission should release all available information regarding the value of the licenses because this tends to make the information held by bidders more similar, which raises average sales prices thereby inducing a more efficient allocation of licenses.

C. Advantages of the Recommended Auction Over Use of Oral Auctions

Multiple rounds of sealed-bids capture a number of advantages over the Commission's proposed use of oral auctions. These advantages are as follows.

1. More information released by the auction to bidders

The primary difference in the release of information between simultaneous sealed-bid auctions and the Commission's proposed sequence of oral auctions is that in the former, bidders can gather information regarding how other bidders value all the licenses, while in the latter, bidders can only gather information on the current license and licenses sold in prior oral auctions. This ability to pool information regarding the values of many PCS licenses simultaneously will assist bidders in more accurately estimating the values of the licenses for which they bid. Thus, simultaneous, sealed-bid auctions with several rounds of bidding will be efficient because they will award licenses to the applicants who value them most highly.

2. Bidders can consult with management and consortium partners

As a practical matter, firms are not likely to give a single individual or even a team of bidders much discretion in making bids that may be in the range of tens to hundreds of millions of dollars. Therefore, bidders are likely to be told by management to bid up to a given level and no higher. The effect of this is to prevent the companies from using information released by the auction. Effectively, an oral auction becomes equivalent to a second-price auction,[8] because each bidder will have a dollar value that they may bid, and the price obtained will be the second highest such value. This inability to revise the bids based on information release prevents oral auctions for PCS licenses from permitting the revision of bids which constitutes the primary advantage of an ascending bid auction.

3. Permits concealment of identities of bidders

Unlike oral auctions, multiple rounds of sealed-bids permit the Commission to keep the identities of the bidders secret, thereby making collusive agreements more difficult to enforce and generally discouraging collusion. However, explicit collusive agreements, where bidders meet prior to an auction to agree to restrain competition, rarely involve large corporations. Explicit collusion carries mandatory prison sentences under the 1987 Federal Sentencing Guidelines. It is difficult to motivate managers to risk prison in order to obtain the benefits of explicit collusion, since these benefits primarily accrue to the shareholders of the corporation. Indeed, explicit collusion is generally found only among

[8] A second-price sealed-bid auction is an auction wherein each bidder submits a bid, and the high bidder pays the second highest bid.

small firms that are owner-operated, so that those bearing the risk of imprisonment capture the benefits of the risky collusive behavior.[9]

Implicit collusion, where bidders do not discuss the sharing of the market, but nevertheless do not compete fully, is probably much more common. Implicit collusion involves a mutual understanding that if none of the firms compete vigorously, all will earn higher profits. Both explicit and implicit collusion rely on bidders knowing their competitors. Either type of collusive behavior will tend to break down if competition comes from outside firms, shrinking the size of the market available to the collusive group. Since the oral auctions proposed by the Commission would enable the bidders to know their competitors, implicit collusion and the resulting lower prices are more likely to occur than with repeated rounds of sealed bids.

4. Auctions can be run simultaneously

Oral auctions, which require a bidder to be present, are necessarily sequential. This means the Commission must cleverly choose the order in which the auctions are operated in order to obtain an efficient outcome. Since it is not at all clear which order is best, this creates a difficult problem for the Commission and increases the likelihood of deterring efficient aggregations of licenses. In contrast, running the auctions simultaneously permits the bidding to determine the ordering of closing of the auctions, thereby facilitating optimal license aggregations.

It is not obvious that ordering the licenses from the most populous MTA to the least populous MTA, as suggested by the Commission, is optimal. With such an ordering, the most valuable licenses are auctioned first. This means that information from less

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[9] See McAfee and McMillian (1992), "Bidding Rings," *American Economic Review.*

valuable licenses, relevant to bidding on the more valuable licenses, will not be available when the more valuable licenses are auctioned.

In contrast, multiple rounds of sealed-bids permit bidders to condition all of their bidding behavior on observations about bidding in the other auctions. This allows the maximal amount of information to be applied in the auctions where it matters most: the last auctions to close. For this reason, multiple rounds of sealed-bids will likely require less use of after-market trading than sequential auctions.

In particular, the "hold-up" problem, wherein one bidder obtains a part of an efficient aggregation and then tries to extort the holder of the remainder by charging a high price, will be less severe in simultaneous auctions. Any key piece to an efficient aggregation of licenses will tend to close late in the auction, and therefore after the information about the aggregation has already become clear. Thus the bidder willing to pay the most will win the license. In contrast, in sequential auctions it is possible for a bidder to buy a single license early and then have it become clear later that another bidder values it more, after that other bidder's purchases are made. Sequential auctions, thus, encourage this type of inefficient allocation of licenses to occur.

5. Auctions can be completed more rapidly

It seems reasonable to suppose that it will take approximately one business day per oral auction. This means that it will take ten years to allocate all the PCS licenses by sequential oral auctions.[10] In contrast, even if it takes a month to run multiple rounds of sealed bids, the PCS auctions would likely be completed in less than one year.[11]

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[10] Since there are 51 MTAs for Channel Blocks A and B, and 492 BTAs for Channel Blocks C, D, E, F, and G, the total number of oral auctions would be 2,562. At the rate of one auction every business day, these auctions would take ten years to complete.

[11] This assumes that the 30 MHz licenses each take a month and that each channel block of the remaining licenses takes two months, by auctioning half the BTAs at a time.

6. Encourages efficient geographic aggregations

In order to promote efficient aggregations of geographic regions, I recommend that the auctions for a given block of spectrum be carried out simultaneously. This permits bidders to make interdependent bids, and in particular to raise one bid given success in another auction. Oral auctions, which are necessarily sequential because a bidder cannot be in two places at once, permit bidders to base their bids in later auctions on the outcome of earlier auctions (see Notice at ¶ 51). Oral auctions will bias the outcomes towards particular kinds of aggregations, basically centered around the properties auctioned first, and discourage aggregations of properties auctioned late in the sequence (see Notice at ¶ 52).

In contrast, simultaneous auctions permit the bidders to bid aggressively on the aggregation of their choice, allowing the market decide which aggregations should arise. This appears important because some unusual but sensible aggregations of cellular licenses have arisen, such as the combination of licenses along major interstates held by GTE/Contel in the Southwest and McCaw/LIN in the Northeast. Moreover, given the somewhat "patchwork" nature of existing cellular licenses, it seems likely that cellular companies, seeking to fill out or complete regional areas, will bid aggressively on geographic aggregations that are difficult or impossible to predict in advance. These considerations lead to the conclusion that it is important to permit the market to choose the types of geographic aggregations that make good business sense rather than have the Commission attempt to predict these aggregations in advance of the auction.

Furthermore, using simultaneous auctions, bidders can aggressively pursue a subset of the licenses of their choice, without the threat of a hold-up problem that arises out of the accidental ordering of the licenses under sequential auctions. For example, if a national license is optimal, a bidder can keep bidding for all the MTAs until it has won

them all. Similarly, the auction facilitates aggregation of regional-sized licenses, the composition of which are determined by market forces and not by the auction form itself.

7. Provides more data for evaluation by Commission

In oral auctions, only the number of participants and the eventual winning bid become apparent. In contrast, multiple rounds of sealed-bids provide more information and will permit the Commission to perform a more complete analysis of the bidding. In particular, the Commission may observe that a particular applicant drops out of several auctions on the same round, and therefore be able to estimate what set of licenses that applicant was pursuing and at what point the prices of the licenses became too high for it. This will shed light on applicants' strategies in bidding on PCS, and provide a basis for the Commission to evaluate the sale's success at promoting efficient aggregations and for understanding the form of competition in the PCS market.

8. Increases expected government revenues

Multiple rounds of sealed-bids enhance government revenue over both oral and first-price, sealed-bid auctions. This is because multiple rounds of sealed bids release more information to the bidders, which enhances government revenue,[12] than either first-price, sealed-bids or oral auctions. First-price, sealed-bid auctions, of course, release no information. Oral auctions tend to release less information than multiple rounds of sealed-bids because typically at any moment only two bidders are involved in the actual bidding. Thus information about firms not currently bidding, as to whether they are willing or not to pay the current price, is unavailable. In contrast, using multiple rounds of sealed-bids,

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[12] See Milgrom and Weber (1982), "A General Theory of Auctions and Competitive Bidding," *Econometrica,* 1982.

the Commission can choose to release *all* of the current bids, thereby releasing a maximal amount of information about the bidders' willingness to pay.

D. Advantages of the Proposed Auction Design Over the Use of Sealed Bids for a National License

As noted, the value of a license in one geographic area will likely depend on whether a given firm wins licenses in other geographic areas. This interdependency of the values of licenses in different areas raises the major issue of how to use the auction form to facilitate the assembly of efficient aggregations of geographic areas. A full solution to this problem would probably involve complete combinatorial bidding, i.e., allowing the bidders to bid on every possible geographic configuration of licenses. This solution has two serious defects. First, it is computationally prohibitive. In particular, there are 2,251,799,685,247 possible sets of MTAs on which a firm could bid. Second, it admits the possibility of perverse outcomes, known as *bullying equilibria*. A bullying equilibrium arises when some bidders have pessimistic, self-fulfilling beliefs. For example, firms may believe that no one will submit serious bids in the auctions for individual MTAs because those licenses will almost certainly be won by a bidder for a national license. As a result of what the Commission terms the *free-rider* problem (see Notice at ¶ 62), no bidder has an incentive to submit nontrivial bids for individual MTAs, because they can not unilaterally overcome bidding on a national license.

The Commission has proposed two combinatorial schemes: bidding on national 30 MHz licenses and bidding on MTA licenses for the other channel blocks auctioned individually at the BTA level. I will focus my discussion on the national license; the logic for the other channel blocks is analogous. Ignoring for a moment the free-rider problem, *the Commission's proposal makes sense only if a national license is likely to be the only important geographic aggregation in the auction.* If, in contrast, the efficient allocation is

a small number of large blocks (e.g., east and west), then facilitating a national license makes little sense and can lead to severely inefficient outcomes, even ignoring the free-rider problem, because the national license may sell even when it should not.[13]

To give a concrete example, suppose there are three firms, *E*, *W*, and *N*, and three licenses, East, West, and National. Firms' valuations of the licenses are as follows.

	East	West	National
Firm *E*	$2.0 billion	$1.0 billion	$3.0 billion
Firm *W*	$1.0 billion	$2.0 billion	$3.0 billion
Firm *N*	$1.6 billion	$1.6 billion	$3.3 billion

Suppose first that there is no separate auction for the national license, rather all three firms bid for the East and West. The outcome of the auction for the East is that Firm *E* wins with a bid slightly in excess of $1.6 billion, thereby exceeding firm *N's* willingness to pay. Similarly, the outcome of the auction for the West is that firm *W* wins with a bid slightly in excess of $1.6 billion. This outcome is the efficient one because the auction awards the licenses to the firms that have the highest valuations. That is, both firms *E* and *W* value the licenses at $2 billion each, or $4 billion in aggregate. Of this total amount, the government collects slightly in excess of $3.2 billion from the proceeds of the auction.

Suppose now that a national auction were held, as well as the individual auctions for the East and West. Firm *N* has no incentive to participate in the East and West auctions, because it will win the national auction. In the individual auction for the East,

[13] This is especially important in PCS auctions, where many of the potential bidders hold cellular licenses and therefore face large costs of participating in a national license auction (essentially being required to sell off their cellular operations).

firm *W* drops out at $1.0 billion. Therefore, firm *E* has the highest bid, slightly in excess of $1.0 billion. Similarly, firm *W* has the highest bid in the West, also slightly in excess of $1.0 billion. In the separate national auction, firm *N* wins with a bid slightly in excess of $3.0 billion, because firms *E* and *W* drop out at that price. Therefore, the price obtained for the national license exceeds the sum of the prices on the East and West auctions, and firm *N* wins the national license. Firms *E* and *W* obtain no licenses. This outcome is not efficient because the total value created is only $3.3 billion (firm *N's* valuation) rather than $4 billion (firm *E's* and *W's* combined valuation). Moreover, the revenue to the government falls, compared to when there was no separate auction for a national license, from approximately $3.2 billion to $3.0 billion.

Now suppose, in contrast, that firm *N* values the nation at $4.1 billion, i.e., more than firms *E's* and *W's* combined valuation of the national aggregation, and leave all other assumptions the same. If there were no separate auction for a national license, firm *N* would win both the East and the West auctions with bids slightly in excess of $2 billion each. This outcome is the efficient one since the total value created (i.e., firm *N's* valuation of $4.1 billion) is maximized. Of this total value, the government would collect slightly in excess of $4.0 billion. Thus, simultaneous bids for the East and West, with no separate auction for a national license, results in the efficient assembly of a national aggregation when that is the highest valued use of the spectrum. Finally, if there were a separate auction for a national license, firm *N* would win with a bid slightly in excess of $3.0 billion, thus reducing revenue to the government.

This example is extreme to illustrate the problem with a national license in the most simple fashion. However, the logic of the example carries over to the more realistic case where the bidders are uninformed about the others' willingness to pay. To obtain efficient aggregation, the auction must permit bidder *N* to drop out of the individual auctions when the sum of prices reaches firm *N's* willingness to pay, which requires the auctions to be simultaneous.

Finally, government revenue is typically higher with individual auctions. A firm bidding for a national license has little incentive to bid aggressively in the individual auctions, for by doing so, it makes its national bid less likely to succeed.

III. Recommended Auction Design

As described above, the basic form of the recommended auction is to employ several rounds of sealed bids in which all the geographic areas for a given spectrum block are auctioned simultaneously.[14] In discussing the recommended auction design, I will use a 30 MHz license as an example. The other licenses can be auctioned in an analogous fashion. The auction proceeds by a series of rounds. Before each round and for each MTA, the Commission or it agent will announce:

1. the "minimum valid bid,"
2. the "suggested minimum bid,"
3. the list of bids received in the previous round, and
4. the due date for bids.

In the first round, any positive bid is valid. The "suggested minimum bid" in the opening round is an amount at which the Commission expects most licenses will sell. For example, suppose the Commission expects that most license rights will sell for $0.30 per MHz per person in the MTA.[15] For an MTA with a population of ten million, this would lead to a

[14] Given that there are only 51 MTAs, it is feasible and useful to auction all 102 Channel Block A and B licenses in the 51 simultaneous MTA auctions. Such auctions would award the PCS licenses more rapidly and, by reducing the winner's curse, increase government revenues. The details of how these auctions would proceed are provided in Appendix C.

[15] This dollar value equals half of the congressional estimate (see Notice at footnote 98). The minimum suggested bid should be revised based on the selling prices in the early

suggested minimum bid for a 30 MHz license of $90 million = $0.30 x 30 MHz x 10 million. With respect to the bids received in the previous round, there are of course no bids to reveal in the opening round. I suggest that the bidders be given three business days to respond, so that the due date for bids is just the date of announcement plus three business days.[16]

Subsequent rounds proceed in a similar fashion. Having received the bids from the previous round, the Commission prepares a sheet listing the dollar values of the bids, *but not the identities of the bidders.* A sample sheet is provided in Appendix B. The "minimum valid bid" is the maximum bid from the previous round. The "suggested minimum bid" is the minimum valid bid plus an increment chosen to ensure rapid completion of the auction. I suggest that five percent might be a reasonable increment, trading off the desire to complete the auction rapidly with the desire to release information. Large minimum increments make the auction proceed in large steps, reducing the revelation of information.

The auction proceeds to the next round if at least two bidders submit bids as large as the suggested minimum bid. The auction also continues if no bidder submits a bid in excess of the suggested minimum bid, and there is a tie for the highest bid. Thus the auction can end in one of two ways:

1. No bids submitted,

2. Bids submitted, but less than two in excess of the suggested minimum bid.

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auctions. For example, if it were found that 90 percent of the first 100 auctions produced prices in excess of $0.45 per MHz per person, the suggested minimum bid might be revised upward to this value.

[16] This time period could be lengthened or shortened depending on the Commission's preference in the trade-off between allowing applicants to deliberate and completing the auction expeditiously.

In the first case, with no bids submitted in the current round, the high bidder from the previous round is awarded the license at a price equal to her bid. The only exception arises in the first round; no one wins the auction in this case and the Commission retains the license. This exception should not arise unless the license is literally worthless, as otherwise some qualified bidder has the ability to submit a bid of one penny and win the license.

In the second case, the highest bidder in the current round wins the license at a price equal to that bidder's bid. In the event of a tie for the highest bid, with all bids strictly below the suggested minimum bid, the auction continues.

Winning bidders should be allowed to withdraw from winning a license, only forfeiting the $0.02 per person per MHz up-front payment for a withdrawal, in order to avoid circumstances in which an applicant wins more licenses than it intended. This type of "regret" on the part of buyers is more likely to arise in sequential oral auctions than in multiple rounds of sealed bids. The reason being that in sequential oral auctions, bidders in one auction have no knowledge of how licenses in future auctions will be valued by other bidders. Whereas in simultaneous sealed-bid auctions, bidders can learn about other bidders' valuations and so form more accurate estimates of the values of the licenses on which they bid. The ability of buyers to more accurately estimate the values of licenses reduces the likelihood that they will either fail to acquire those licenses for which they have the highest valuation or pay too much.

If a withdrawal occurs, the winner of the auction is the second highest bidder. Notice that if the auctions had been oral as proposed by the Commission, a withdrawal would necessitate a second auction. By contrast, with the use of sealed bids, the second highest bidder can be readily observed and no new auction is required.[17]

[17] The auction would only need to be re-opened in the unlikely event that two or more firms submitted identical, second highest bids.

Provided the suggested increment is small, withdrawals should be rare, because it is unlikely that too many auctions will close on the same round. Further, even when this occurs, it is likely that a given bidder will not have won more than it desired. Nevertheless, it is important to allow the bidders the flexibility to bid on several licenses when they only want one, in order to encourage aggressive bidding on all licenses. Moreover, the forfeiture of the up-front payment discourages bidders from using shell or dummy corporations to make multiple bids, hoping to withdraw some, since they must pay approximately their savings from a withdrawal.[18] Finally, even when withdrawals occur, the government will likely lose little if anything from the withdrawal.[19]

With respect to the timing of when the simultaneous auctions will end, there is a simple strategy the auctioneer can follow to ensure that the auctions end approximately at the same time: make the size of the suggested increments depend on the number of active bidders. For example, if the increments were reduced to one percent when there were four bidders, one-half percent when there were three bidders, and one-fourth percent when there were two bidders, auctions would slow down before closing. This would tend to cause the prices for all of the licenses to be established at approximately the same time.

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[18] If the suggested increment were equal to the up-front payment, of course, it would never be profitable to use a shell or dummy corporation to submit a second bid. However, even with a five percent increment and a $0.02 per MHz per person up-front payment, it will still not generally be profitable to utilize multiple bidders. The reason is that if a firm withdraws its winning bid, there were at least two bidders at the previous round, and thus a firm withdrawing a bid may not hold the highest bid from the previous round.

[19] For example, assume that the market price is approximately $0.60 per MHz per person (see Notice at footnote 98), and suppose the winning bidder drops out at this level. Then, with a five percent suggested increment, the previous bids were $0.57 per MHz per person. Thus, when the winning bidder exits, the government obtains $0.57 per MHz per person for the license, but also retains the $0.02 per MHz per person up-front payment, for a total of $0.59 per MHz per person. Requiring the bidder to pay the up-front payment leaves the government collecting approximately the same revenue as if the bidder had not withdrawn, yet gives the bidders the ability to withdraw from winning bids.

In sum, the recommended auction design represents a formalization of the way most very large private business transactions take place. Most transactions in the range of tens or hundreds or million dollars represent the sale of companies or divisions. Typically a small set of interested bidders is identified, which is analogous to the qualification process used by the Commission. Bids are solicited by the seller, generally the board of directors of the company being sold, and these bids are announced. New bids are then solicited which must exceed the maximum prior bid. Solicitation of bids continues until only one bidder remains.

Of course, private business is permitted to use informal selling procedures not available to the government. The recommended auction design mimics the way large corporations are sold within a simple set of rules that ensure an open and fair auction, avoiding the informal bargaining and discretion used in private sales. It is important to note that most private transactions in the tens of millions of dollars are *not* made in oral auctions, probably because consultation and deliberation are too important for obtaining a fair market price when the stakes are so high.

IV. Designated Entities

It is not uncommon for the government to wish to encourage the participation of some group by favoring them in auctions. There are two main methods used to implement such preferences: set-asides and price preferences (also know as bidding preferences or bidder credits). Set-asides are the more common method, while price preferences have primarily been used to favor domestic suppliers over foreign suppliers, both by the Buy American Act, which specifies 6-12 percent preferences, and also by the Department of Defense, which uses preferences of up to 50 percent. In addition, price preferences have been

frequently used in Canada, and to a lesser extent by other industrialized nations, to favor various groups.

Price preferences operate by permitting designated entities to bid lower and still win the auction. For example, suppose that small businesses are given a ten percent preference. If a small business bids $1,000 and wins the auction, its payment to the government will be $900 (i.e., 90 percent of $1,000).

Price preferences could be applied to all of the auctions rather than to just a portion of them. One may view a set-aside as an infinite price preference applied to only a portion of the auctions. Price preferences have a number of advantages over set-asides.

1. Price preferences increase competition in all auctions

Designated entities are generally designated for favoritism because they are disadvantaged in some way. For example, small businesses may have difficulty competing because of capital constraints. Price preferences undo these disadvantages, making the designated entities more effective competitors in all of the auctions. In comparison, the use of set-asides typically means that only large businesses compete in the auctions not set aside, while only small businesses compete in the auctions set aside. In both cases, competition is increased by using price preferences. In the formerly set-aside auctions, there is participation by large business. In the auctions that were not to be set aside, there is more effective competition by small business. In both cases, a more competitive environment results.

2. Price preferences establish values for implementation of the unjust enrichment provision

One of the major issues raised by set-asides is how to deal with sales by designated entities to others (see Notice at ¶¶ 86 and 88). Typically what must happen is that the value of the license, were it not set-aside, must be estimated, and the difference between this value and the actual sale price estimated with the difference rebated to the government. Alternatively, the government may require the difference in the actual sale price and the amount paid rebated to the government, which effectively prevents resale no matter how valuable the exchange might be.

In contrast, a price preference creates a natural measure of the value of the license: the amount of the preference. Thus, if a ten percent preference were used, a sale of a license by a preferred group to a non-preferred group should carry a ten percent rebate to the government. That is, ten percent of the actual winning bid, for this is precisely the amount that the undesignated entity could have bid and won the license. Thus, thorny issues about exchange are handled naturally by price preferences.

3. Price preferences reduce inefficient sales

Set-asides put licenses in the hands of designated entities no matter how inefficient this might be. For example, a license worth $10,000,000 to a undesignated entity could sell for $10,000 under set-asides. With price preferences, such extreme disparities are not permitted. Price preferences allocate licenses to designated entities when these are sufficiently close in value, and not otherwise, where sufficiently close is determined by the magnitude of the price preference. Price preferences ensure that there is a minimal social loss associated with favoring the designated entity.

4. Price preferences increase government revenues

Price preferences maximize government revenue subject to the constraint that designated entities win a given portion of the licenses on average.[20] That is, there is no less expensive way to ensure a given level of participation by designated entities than price preferences.

In addition, price preferences may increase government revenue even when compared to no favoritism at all. This is because price preferences create more effective competition. That is, the government may collect more revenue using price preferences than if it ignored the designated entities.

5. Price preferences do not create "ghetto licenses"

Set-asides banish favored groups to particular set-aside licenses, which tend to be the less valuable and useful ones. By using price-preferences, disadvantaged groups have a chance of winning any of the licenses, bringing them more into the mainstream of wireless communication.

6. Price preferences are a versatile instrument

Unlike set-asides, it is possible to provide distinct preferences to various designated entities. For example, small business could be given a ten percent preference, while rural telephone companies that do not qualify as small business could be given a five percent preference. Thus, the level of preferences can be adjusted to encourage participation by a

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[20] See McAfee and McMillan (1989), "Government Procurement and International Trade," *Journal of International Economics.*

variety of groups of bidders, in spite of the fact that promotion of one group may conflict with promotion of another group.

Moreover, the level of preferences can be adjusted to achieve the desired goals. Thus, if the designated entities are nearly competitive with the undesignated firms, then a small price preference will suffice to ensure that the designated entities win a portion of the contracts. On the other hand, if the designated entities are not so close to the undesignated entities, than larger preferences may be necessary.

7. Price preferences can be used for partial ownership

One issue that arises with minority-owned business is the extent to which set-asides really create minority participation in the auction. Minorities may have nominal control of a company, which is effectively controlled by non-minorities. A solution to this problem arises by having the size of the preference related to the percentage control.

For example, suppose minorities are given a twenty percent preference. Then a business with sixty percent minority ownership would be given sixty percent of the twenty percent preference, or twelve percent. The advantage to such preferences is to reward firms with greater minority participation by greater preference in the auction. Moreover, such a system can encourage minority participation even in firms controlled by non-minorities.

Furthermore, partial application of preferences for partially owned minority business permits the government to require a payment if the minority ownership level is reduced. For example, a firm that goes from sixty percent to forty percent minority ownership would rebate twenty percent of its preference to the government. If the preference were thirty percent, this would require a rebate of twenty percent of the thirty percent price preference, or six percent of the winning bid.

8. Disadvantage of Price-Preferences

The only disadvantage of price preferences is the difficulty of assessing an appropriate level of preference to implement a desired level of participation by the designated entities. This problem is solvable, either by experimenting with 10 MHz licenses, or by observing the sale without preferences of some 10 MHz licenses, and then calculating how closely the designated entities came to winning. If, for example, the designated entities bid on average ten percent less than the others, a preference of ten percent would be reasonable to level the playing field.

V. Experimentation and Evaluation

The large number of BTAs to be auctioned provides an opportunity to experiment with the form of the auction and observe which designs encourage efficiency and returns to the government. In general, experiments should compare similar properties, so that as many factors as possible are held constant. This will make the comparison as clear as possible. A *paired* experiment, for example, could consist of the auction of two 10 MHz licenses in the same BTA. Generally, comparing the results on BTAs that are similar in terms of population, geographic size, residential versus commercial land use, per capita income, and characteristics of surrounding areas would be desirable. If many factors differ between two auctions, the results of the experiment will be difficult to interpret. In addition, it is clearly desirable to begin the experiments with the lowest value licenses. This ensures that mistakes are less costly and that the knowledge gained from the experiments can be applied to the highest value licenses. Thus, the preliminary experiments should be conducted with auctions for 10 MHz licenses.

The auction design proposed in section III contains several characteristics that would benefit from experimentation. These include:

1. the increment for the suggested minimum bid;
2. the information released to bidders;
3. the initial suggested bid; and
4. the level of price preference.

The increment for the suggested minimum bid trades off the speed at which the auction is completed against the detail of the information released. Thus, a ten percent increment completes an auction before a five percent increment on average, but the ten percent increment yields coarser information regarding bidders' valuations of the item for sale. That is, bidders learn the values associated with bidders who drop out of the auction only to ten percent accuracy rather than to five percent accuracy. Also, a ten percent suggested increment increases the likelihood that the auction will end with a round of no bids and the winner being the highest bid in the previous round.

Auctioneers generally choose the increment based on the intensity of competition. If it appears that many bidders are willing to pay the going price, the auctioneer might use large increments such as 25 percent to increase the price rapidly to a point where few bidders remain. At that point, the auctioneer will decrease the increments to five or ten percent, and later to one or two percent as the auction nears completion in an attempt to extract the last dollar from the bidders.[21] Thus, in addition to experimenting with the size

[21] Note that the suggested minimum bid is a substitute for the auctioneer's behavior, because it induces a bidder to bid close to her value to stay in the auction when she would rather see if anyone else would drop out. For example, if a bidder valued a license at $1,000,000, and the current price were $900,000, a bidder might bid $950,000 rather than a lower amount and risk losing the license because the smaller amount was less than the minimum increment.

of the increment, the Commission may want to experiment with using increments related to the number of bidders (see discussion in section III).

A second avenue for experimentation is the information released to the bidders. Clearly an ascending bid auction must release the maximum bid from the previous round. Releasing other information involves a tradeoff. Information about the other bids is useful in assessing the value of the license and reducing the winner's curse. However, information about the number of other bidders may reduce the level of the winning bid. Thus, the Commission could experiment with releasing only the maximum bid; releasing all the bids; and releasing the maximum and minimum bids in order to determine which information release yields the best outcomes.

A third avenue for experimentation is the suggested minimum bid for the opening round. Since this bid affects how quickly the auction closes, it would be useful to experiment with different criteria for determining this suggested bid.

Finally, the level of price preferences necessary to involve designated entities can be assessed by experimentation. A strategy in this regard is to auction twenty 20 BTAs (a large enough number to draw reliable statistical inferences) with no preference and 20 BTAs with a five percent price preference for designated entities. The outcome of these sales can be used to observe whether five percent is sufficient to obtain the desired level of wins by the designated entities. If not, then increase the price preference to ten percent and so on until the desired level of wins is obtained.

With respect to post-auction evaluation by the Commission, the use of multiple rounds of sealed bids offers a basic advantage over oral auctions. Namely, that much more information concerning bidders' valuations and bidding strategies will be available. This information will be useful for conducting future auctions and for permitting the Commission to determine the success of the auctions at setting competitive market prices for PCS licenses.

VI. Summary and Conclusions

Given the goals of simplicity, efficiency, and revenue, the licensing of PCS spectrum is best accomplished by simultaneously auctioning the licenses using several rounds of sealed bids. Simultaneity ensures that the auctions do the best job of creating efficient aggregations without the excessive use of after-market sales likely to arise with sequential auctions.

Oral auctions have three major defects when compared to auctions with several rounds of sealed bids. First, oral auctions are necessarily sequential, which makes efficient aggregation difficult. In particular, oral auctions raise the problem of correctly ordering the sales. This requires the seller to forecast the efficient aggregations, which seems impossible to know in advance. It is preferable to let the market choose the aggregations that make good business sense. Such market choice requires simultaneous bidding.

Second, oral auctions permit bidders to observe the identities of their competitors, raising the likelihood of implicit collusion by rivals. While explicit collusion is unlikely given the size of the bidding firms, exposing the identities of bidders is likely to lead to less intense competition than would arise with anonymous auctions.

Third, oral auctions reduce the ability of bidders to consult with management or consortium partners and eliminate the opportunity for careful deliberation in bidding. Thus, the speed at which an oral auction operates eliminates the major advantage of oral auctions over one-time, sealed-bids: The incorporation of information regarding other firms' bids into the bidding process.

The extra release of information, along with careful deliberation by the bidders in forming their bids, allowed by the recommended auction, will lead to (1) more efficient aggregations of licenses; (2) higher average prices for the licenses; and (3) more informed decisions by applicants, i.e., less regret. The recommended auction forces prices closer to the maximal values of the licenses, because the licenses are allocated more efficiently and